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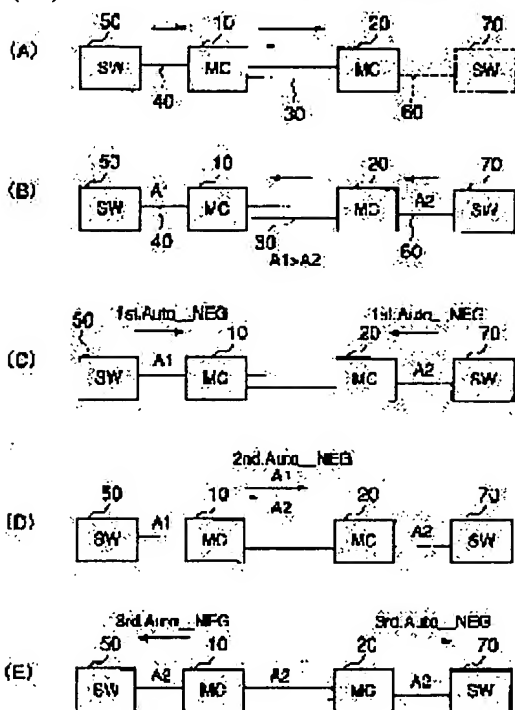
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#### (54) MEDIA CONVERTER AND ITS AUTOMATIC NEGOTIATION METHOD



(57)Abstract:

PROBLEM TO BE SOLVED: To provide a media converter which correctly transmits a line ability and also to provide an automatic negotiation method.

SOLUTION: A first automatic negotiation (1st.Auto-NEG) is performed with a metal cable and the first line ability (A1) is set. A second automatic negotiation (2nd.Auto-NEG) is performed with an optical fiber cable based on the first line ability and the second line ability (A2) is set. Then a third automatic negotiation (3rd.Auto-NEG) is performed with the metal cable again based on the second line ability and the line ability (A2) between the metal cable and the optical fiber cable is finally decided.

#### [Brief Description of the Drawings]

[Drawing 1] It is a block diagram showing one embodiment of the Gigabit Ethernet using the media converter by this invention.

[Drawing 2] It is a state transition diagram of the program included in FPGA in one embodiment of the media converter by this invention.

[Drawing 3] It is an explanatory view showing one embodiment of the auto negotiation procedure by this invention.

[Description of Notations]

10 Media converter

20 Media converter

30 Fiber optic cable

40 Metal cable

50 Switch  
60 Metal cable  
70 Switch  
101 Physical layer device  
102 Physical layer device  
103 FIFO memory  
104 FPGA  
201 Physical layer device  
202 Physical layer device  
203 FIFO memory  
204 FPGA

### **[Detailed Description of the Invention]**

[0001]

**[Field of the Invention]** This invention relates to the network of a gigabit class, and relates to the media converter and the auto negotiation method which are especially used for such a network.

[0002]

**[Description of the Prior Art]** When a Local Area Network (LAN) connects by network two or more computers, a server, a printer, etc., it is an indispensable network. Especially Ethernet (registered trademark) system LAN art is that standardization of 1000BASE-X (IEEE802.3z) and 1000BASE-T (IEEE802.3ab) was completed recently, and is becoming the leading role of the high-speed multimedia network age.

[0003] Such LAN can lengthen a communication range by using an optical fiber. That is, a communication range is extensible by forming a media converter in the both ends of the link between adjoining nodes, respectively, and relaying a metal cable with a fiber optic cable.

[0004] A fiber-optics circuit is extended to each home, and FTTH (Fiber To The Home) which can exchange music, video, medical data, etc. free by a high speed line is attracting attention in recent years. When the FTTH age comes, the media converter which connects a fiber-optics circuit to the metal cable of an office or a domestic computer is needed. Thus, a media converter is communication equipment indispensable to a future high-speed multimedia network.

[0005] The port and UTP (Unshielded Twisted Pair) for generally connecting an optical cable to a media converter. The physical layer device is formed in each of the port for connecting a cable.

Each physical layer device is supporting MII (Media Independent Interface) specified by IEEE802.3 standard.

[0006] On the character of a media converter, when one link is cut, what has the missing link function to cut the link of another side automatically is common. For example, when

an obstacle occurs in a fiber optic cable and is cut, the link by the side of the UTP cable of another side also cuts a media converter automatically.

[0007] When a UTP cable is connected to an optical cable using such a media converter, it is important for a positive flow control to transmit mutual line ability correctly. In particular, in the network of a Gigabit Ethernet system, since the auto negotiation which negotiates for the optimal communicate mode with the partner point automatically, and sets it up is the requisite, it carries out without transmitting line ability correctly, and a positive flow control is not obtained. For example, when two sets of the apparatus by which ability differs are connected, it is necessary to recognize mutual ability by an auto negotiation and to double with a side with lower ability.

[0008]

**[Problem(s) to be Solved by the Invention]** The purpose of this invention is to provide the auto negotiation method in the network which used the media converter.

[0009] Other purposes of this invention are to provide the media converter which can transmit line ability correctly, and the auto negotiation method.

[0010]

**[Means for Solving the Problem]** According to the 1st viewpoint of this invention, an auto negotiation method in a media converter which connects the 1st and 2nd transmission media of a different kind, Perform the 1st auto negotiation by the side of the 1st transmission medium, and the 1st line ability is set up, Based on said 1st line ability, perform the 2nd auto negotiation by the side of the 2nd transmission medium, and the 2nd line ability is set up, Based on said 2nd line ability, the 3rd auto negotiation by the side of said 1st transmission medium is performed, and line ability between said 1st and 2nd transmission media is determined eventually.

[0011] It doubles with the lower one of line ability in the 1st - the 3rd auto negotiation. In the 1st - the 3rd auto negotiation, information about reception of the PAUSE (transmission stop) frame and a transmitting function is transmitted.

[0012] According to the 2nd viewpoint of this invention, a media converter which connects the 1st and 2nd transmission media of a different kind is provided with the following.

The 1st physical layer interfacing means for connecting the 1st transmission medium. The 2nd physical layer interfacing means for connecting the 2nd transmission medium. A memory means for storing temporarily data which is connected between said 1st and 2nd physical layer interfacing means, and is transmitted among them, The 1st line ability is set up by performing the 1st auto negotiation by the side of said 1st transmission medium by said 1st physical layer interfacing means, The 2nd line ability is set up by performing the 2nd auto negotiation by the side of the 2nd transmission medium using said 1st line ability by said 2nd physical layer interfacing means, A control means which determines eventually line ability between said 1st and 2nd transmission media by performing the 3rd auto negotiation by the side of said 1st transmission medium using

said 2nd line ability by said 1st physical layer interfacing means.

[0013] The 1st and 2nd physical layer interfacing means supports GMII (Gigabit Media Independent Interface) specified by IEEE802.3z standard, respectively. When, as for a control means, one physical layer interfacing means changes into an unlinking state further, When a physical layer interfacing means of another side also has a missing link function changed into an unlinking state and a missing link function starts it, it performs again from said 1st auto negotiation to said 3rd auto negotiation.

[0014] Desirably, the 1st medium feed object is a metal cable, and the 2nd transmission medium is a fiber optic cable. It is characterized by a control means being FPGA (Field Programmable Gate Array).

[0015] The 1st media converter that was connected to the 1st device that provides the 1st line ability by the 1st metal cable according to one embodiment of this invention, The 2nd media converter connected to the 2nd device that provides the 2nd line ability by the 2nd metal cable, a fiber optic cable which connects said 1st media converter and said 2nd media converter, and a network, \*\* and others, -- in an auto negotiation method to kick, By an auto negotiation between said 1st device and said 1st media converter, said 1st line ability, The 1st auto negotiation step which acquires said 2nd line ability by an auto negotiation between the 2nd device and said 2nd media converter, respectively, By an auto negotiation between said 1st media converter and said 2nd media converter. The 2nd auto negotiation step which sets up line ability of the lower one for between said 1st media converter and said 2nd media converter among said 1st line ability and the 2nd line ability, An auto negotiation between said 1st device and said 1st media converter determines the lower one as line ability between said 1st device and said 1st media converter among line ability of said lower one, and said 1st line ability, By an auto negotiation between said 2nd device and said 2nd media converter. It is characterized by the 3rd auto negotiation step which determines the lower one as line ability between said 2nd device and said 2nd media converter among line ability of said lower one, and said 2nd line ability, and a thing, \*\* and others.

[0016] As stated above, following [ 1st transmission-medium (for example metal cable) side ] the beginning the 2nd transmission-medium (for example, optical cable) side again by an auto negotiation procedure of three steps of the 1st transmission-medium side. Line ability of both 1st and 2nd transmission media can be transmitted certainly, and a reliable flow control can be attained.

[0017] Also when a link between adjoining gigabit switches is extended by an optical fiber using a media converter, mutual line ability can be certainly transmitted in an auto negotiation procedure of only three steps between switches, and reliable gigabit data transfer becomes possible.

[0018]

**[Embodiment of the Invention]** Drawing 1 is a block diagram showing one embodiment of the Gigabit Ethernet using the media converter by this invention. Here, in order to

explain simply, the gigabit media converters 10 and 20 are connected with the fiber optic cable 30, Furthermore, the media converter 10 illustrates the network with which it is connected to the switch 50 by the metal cables 40, such as a UTP cable, and the media converter 20 is connected to the switch 70 by the metal cable 60, respectively.

[0019] In drawing 1, the physical layer devices (PHY) 101 and 102 are formed in the port of the couple of the media converter 10, respectively, one physical layer device 101 is connected to the metal cable 40, and the physical layer device 102 of another side is connected to the fiber optic cable 30, respectively. Each of the physical layer devices 101 and 102 in this embodiment supports GMII (Gigabit Media Independent Interface) specified by IEEE802.3z.

[0020] Between the physical layer device 101 and the physical layer device 102, The chip which consists of the FIFO (First in First out) memory 103 and FPGA(Field Programmable Gate Array) 104 is formed, and the frequency deviation during transmission and reception can be absorbed by FIFO memory 103. The data received with one physical layer device is written in FIFO memory 103 one by one, is read to the written-in order, and is sent out to the physical layer device of another side. The auto negotiation procedure is included in FPGA104 so that it may mention later.

[0021] The physical layer devices (PHY) 201 and 202 are formed in the port of the couple of the media converter 20, respectively, one physical layer device 201 is connected to the fiber optic cable 30, and the physical layer device 202 of another side is connected to the metal cable 60, respectively. Each of the physical layer devices 201 and 202 supports GMII specified by IEEE802.3z. In addition, the composition and the function of FIFO memory 203 and FPGA204 are the same as that of them of FIFO memory [ of the media converter 10 ] 103, and FPGA104.

[0022] In such a gigabit network, in order to perform a flow control among the switches 50 and 70, the information on line ability (Pause Ability and Asymmetric Pause) is transmitted, and it is arbitrated by the best state. Hereafter, operation of the media converter which realizes the auto negotiation and it by this invention is explained in detail.

[0023] (Operation of a media converter) Drawing 2 is a state transition diagram of the program included in FPGA in one embodiment of the media converter by this invention. Operation is explained taking the case of the media converter 10. Needless to say, the media converter 20 operates similarly.

[0024] First, if one [ a power supply ] (Power#ON), FPGA104 of the media converter 10 will perform the auto negotiation (T-AN1) by the side of the metal cable 40 with the physical layer device 101 (301). At this time, it is assumed that it is in the highest state since the line ability by the side of the fiber optic cable 30 is unknown. By this auto negotiation (T-AN1), negotiation with the correspondence port of the switch 50 by the side of the metal cable 40 is performed here, and a direction [ it is / either / low ] is set as

ability Am1.

[0025] If linkup (link#up) of the metal cable side is carried out, FPGA104 will perform the auto negotiation (X-AN) by the side of the optical cable 30 (302), Mediation by the side of an optical fiber is performed based on ability Am1 set up by the auto negotiation (T-AN1) by the side of the metal cable 40. That is, ability Am1 set up by the auto negotiation (T-AN1) by the side of the metal cable 40 is compared with the ability of the partner point by the side of an optical cable, and it arbitrates so that it may double with lower ability Ao1.

[0026] If linkup (link#up) of the optical cable 30 side is carried out, FPGA104 will perform the auto negotiation (T-AN2) by the side of the metal cable 40 again (303), Mediation by the side of a metal cable is performed based on ability Ao1 set up by the auto negotiation (X-AN) by the side of the optical cable 30. That is, ability Ao1 set up by the auto negotiation (X-AN) is compared with ability Am1 of the partner point by the side of a metal cable, and it arbitrates so that it may double with lower ability Am2. The auto negotiation by this embodiment is completed because the metal cable 40 side carries out linkup (304), and transmission of an Ethernet frame is started between the switch 50 and 70 by the auto negotiation (T-AN2) by the side of the metal cable 40.

[0027] If the link-off (X#link#off) by the side of an optical cable is detected by the physical layer device 102, With the physical layer device 101, FPGA104 starts the missing link (T-DIS) by the side of a metal cable (305), and returns to the auto negotiation (T-AN1) by the side of the metal cable 40. On the contrary, if the link-off (T#link#off) by the side of a metal cable is detected by the physical layer device 101, With the physical layer device 102, FPGA104 starts the missing link (X-DIS) by the side of an optical cable (306), and, similarly returns to the auto negotiation (T-AN1) by the side of the metal cable 40.

[0028] Thus, following [ metal cable side (T-AN1) ] the beginning an optical cable side (X-AN) by an auto negotiation of three steps called the metal cable side (T-AN2) again. The line ability of both the metal cable 40 and the optical cable 30 is transmitted certainly, and it can double with lower ability and can be crowded. Many steps are required if it starts from the auto negotiation (X-AN) by the side of an optical cable. Therefore, reliable gigabit data transfer becomes possible in the auto negotiation procedure of only three steps between the metal cable 40 and the optical cable 30 by the auto negotiation procedure by this embodiment.

[0029] (Operation of a system) Drawing 3 (A) - (E) is an explanatory view showing one embodiment of the auto negotiation procedure by this invention. In order to explain simply, the gigabit media converters 10 and 20 are connected with the fiber optic cable 30 like drawing 1 also here, Furthermore, the media converter 10 illustrates the network with which it is connected to the switch 50 by the metal cable 40, and the media converter 20 is connected to the switch 70 by the metal cable 60, respectively. However, ability by the side of A1 and the metal cable 60 is set to A2, and ability by the side of the metal cable 40 is set to  $A1 > A2$ . For example, the case where the case where it has

reception of the PAUSE (transmission stop) frame and a function of both unsymmetrical functions has only the ability A1 and an unsymmetrical function is the ability A2.

[0030] As shown in drawing 3 (A), when the switch 70 is in a power OFF state, as mentioned above, the media converters 10 and 20 are in a missing link state, and an auto negotiation procedure is not started. If the switch 70 is connected to a network and the missing link state of the media converters 10 and 20 is canceled as shown in drawing 3 (B), an auto negotiation procedure will start.

[0031] First, as shown in drawing 3 (C), the ability A1 of the switch 50 and the ability A2 of the switch 70 are set as the media converters 10 and 20 by the 1st auto negotiation (1st#Auto#Neg), respectively.

[0032] Then, as shown in drawing 3 (D), the ability A1 and A2 set as each is set as a partner's media converter among the media converters 10 and 20 by the 2nd auto negotiation (2nd#Auto#Neg). In other words, it is recognized as the media converter 10 being A2 about the ability by the side of the optical cable 30, and the media converter 20 recognizes the ability by the side of the optical cable 30 to be A1.

[0033] As shown in drawing 3 (E), finally by the 3rd auto negotiation (3rd#Auto#Neg). Again, the media converter 10 performs mediation with the ability A2 by the side of the optical cable 30, and the ability A1 of the switch 50, and the media converter 20 performs mediation with the ability A1 by the side of the optical cable 30, and the ability A2 of the switch 70. Since it is  $A1 > A2$  as mentioned above, according to the ability of the lower one, the switch 50 and the whole segment between 70 are set as the ability A2. In this way, it becomes possible to transmit a gigabit Ethernet frame certainly between the switch 50 and 70.

[0034] For example, supposing it is the ability A2 about the case where it has only the ability A1 and an unsymmetrical function for the case where it has reception of the PAUSE (transmission stop) frame and a function of both unsymmetrical functions, the switch 50 and the whole segment between 70 will be set as the ability which has only an unsymmetrical function. Therefore, in this case, although the switch 50 supports the PAUSE frame reception from the switch 70, the PAUSE frame will be sent out to the switch 70.

[0035]

**[Effect of the Invention]** As explained to details above, according to this invention, first The 1st transmission-medium (for example, metal cable) side, Then, again, by the auto negotiation procedure of three steps of the 1st transmission-medium side, the line ability of both 1st and 2nd transmission media can be transmitted certainly, and the 2nd transmission-medium (for example, optical cable) side can attain a reliable flow control.

[0036] Also when the link between adjoining gigabit switches is extended by an optical fiber using a media converter, mutual line ability can be certainly transmitted in the auto negotiation procedure of only three steps between switches, and reliable gigabit data

transfer becomes possible.

**[Claim(s)]**

[Claim 1]In an auto negotiation method in a media converter which connects the 1st and 2nd transmission media of a different kind, Perform the 1st auto negotiation by the side of the 1st transmission medium, and the 1st line ability is set up, Based on said 1st line ability, perform the 2nd auto negotiation by the side of the 2nd transmission medium, and the 2nd line ability is set up, An auto negotiation method characterized by what the 3rd auto negotiation by the side of said 1st transmission medium is performed based on said 2nd line ability, and line ability between said 1st and 2nd transmission media is eventually determined for.

[Claim 2]An auto negotiation method according to claim 1 doubling with the lower one of line ability in said 1st [ the ] - the 3rd auto negotiation.

[Claim 3]An auto negotiation method according to claim 1 or 2 characterized by transmitting information about reception of the PAUSE (transmission stop) frame and a transmitting function in said 1st [ the ] - the 3rd auto negotiation.

[Claim 4]A media converter which connects the 1st and 2nd transmission media of a different kind, comprising:

The 1st physical layer interfacing means for connecting the 1st transmission medium.

The 2nd physical layer interfacing means for connecting the 2nd transmission medium.

A memory means for storing temporarily data which is connected between said 1st and 2nd physical layer interfacing means, and is transmitted among them.

The 1st line ability is set up by performing the 1st auto negotiation by the side of said 1st transmission medium by said 1st physical layer interfacing means, The 2nd line ability is set up by performing the 2nd auto negotiation by the side of the 2nd transmission medium using said 1st line ability by said 2nd physical layer interfacing means, A control means which determines eventually line ability between said 1st and 2nd transmission media by performing the 3rd auto negotiation by the side of said 1st transmission medium using said 2nd line ability by said 1st physical layer interfacing means.

[Claim 5]The media converter according to claim 4, wherein said 1st and 2nd physical layer interfacing means supports GMII (Gigabit Media Independent Interface) specified by IEEE802.3z standard, respectively.

[Claim 6]When, as for said control means, one physical layer interfacing means changes into an unlinking state further, The media converter according to claim 4 performing again from said 1st auto negotiation to said 3rd auto negotiation when a physical layer interfacing means of another side also has a missing link function changed into an unlinking state and a missing link function starts it.



[Claim 7]The media converter according to claim 4 or 5, wherein the 1st transmission medium is a metal cable and the 2nd transmission medium is a fiber optic cable.

[Claim 8]The media converter according to claim 4, wherein said control means is FPGA (Field Programmable Gate Array).

[Claim 9]The 1st media converter connected to the 1st device that provides the 1st line ability characterized by comprising the following by the 1st metal cable, a fiber optic cable which connects the 2nd media converter connected to the 2nd device that provides the 2nd line ability by the 2nd metal cable, and said 1st media converter and said 2nd media converter, and a network, \*\* and others, -- an auto negotiation method to kick. By an auto negotiation between said 1st device and said 1st media converter, said 1st line ability, The 1st auto negotiation step which acquires said 2nd line ability by an auto negotiation between the 2nd device and said 2nd media converter, respectively. By an auto negotiation between said 1st media converter and said 2nd media converter. The 2nd auto negotiation step which sets up line ability of the lower one for between said 1st media converter and said 2nd media converter among said 1st line ability and the 2nd line ability, An auto negotiation between said 1st device and said 1st media converter determines the lower one as line ability between said 1st device and said 1st media converter among line ability of said lower one, and said 1st line ability, By an auto negotiation between said 2nd device and said 2nd media converter. The 3rd auto negotiation step which determines the lower one as line ability between said 2nd device and said 2nd media converter among line ability of said lower one, and said 2nd line ability.

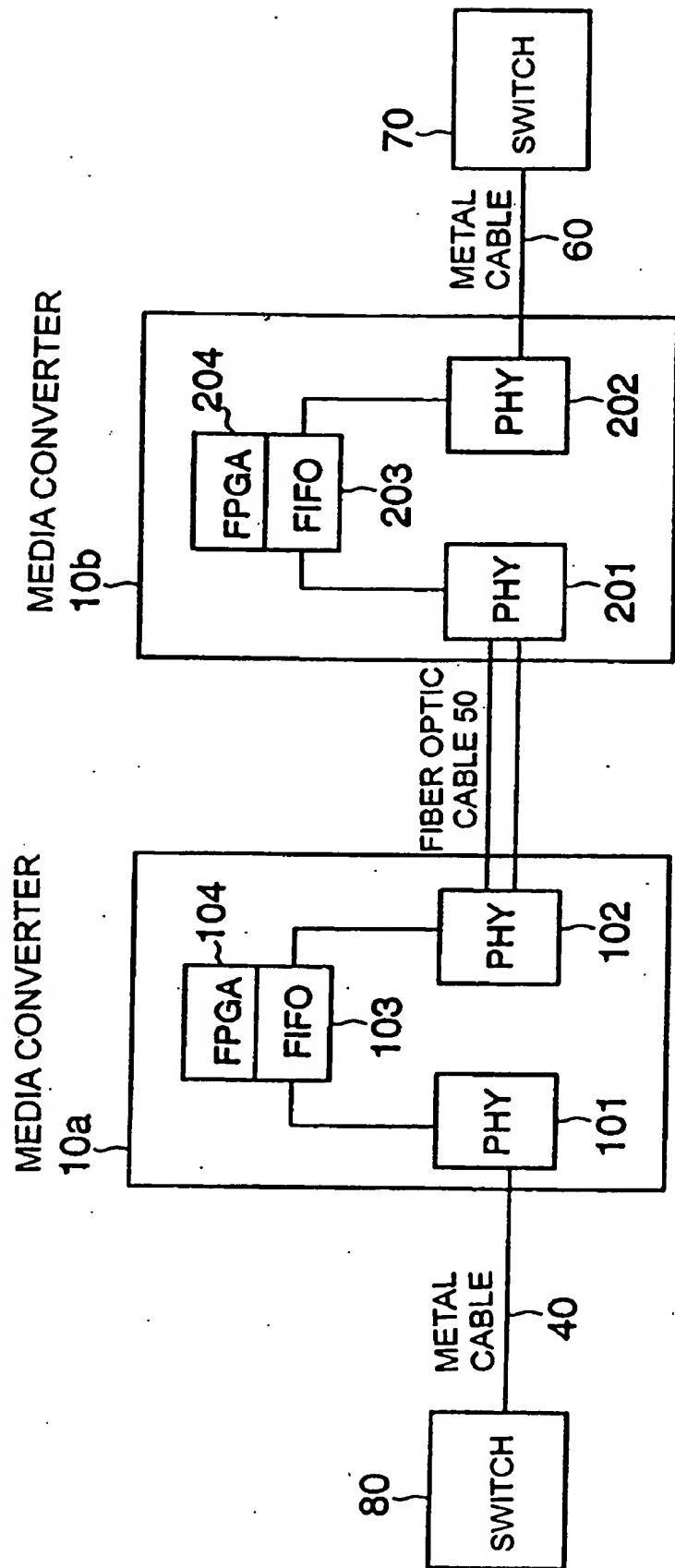
[Claim 10]An auto negotiation control program which specifies an auto negotiation procedure included in a media converter which connects the 1st and 2nd transmission media of a different kind, comprising:

A step which performs the 1st auto negotiation by the side of the 1st transmission medium, and sets up the 1st line ability.

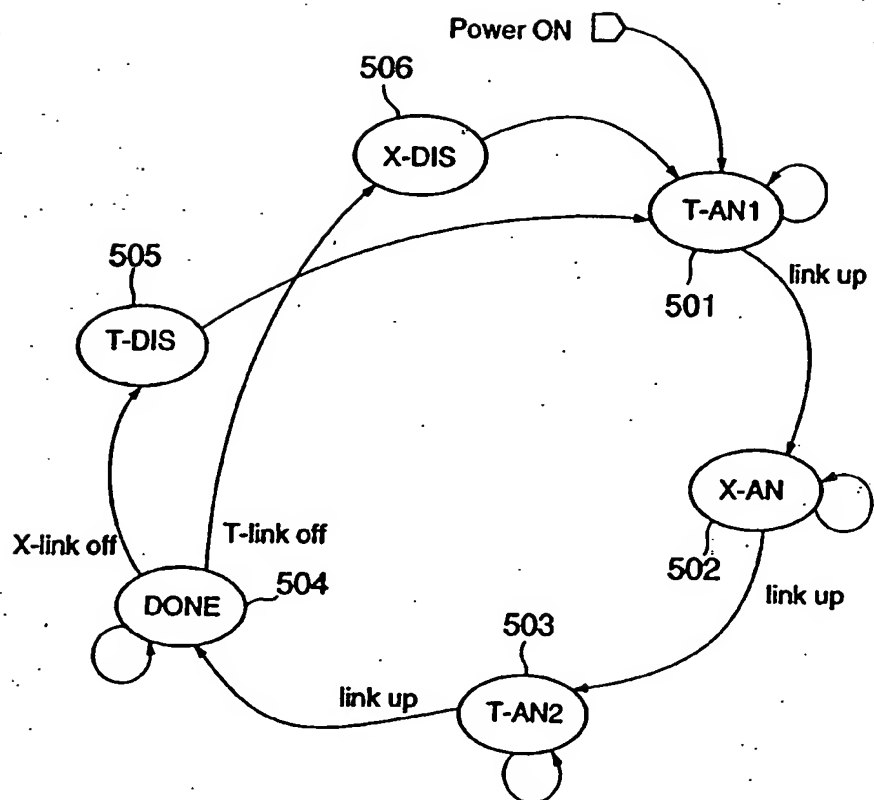
A step which performs the 2nd auto negotiation by the side of the 2nd transmission medium based on said 1st line ability, and sets up the 2nd line ability, A step which performs the 3rd auto negotiation by the side of said 1st transmission medium based on said 2nd line ability, and determines eventually line ability between said 1st and 2nd transmission media.

[Claim 11]A programmable integrated circuit which stored the auto negotiation control program according to claim 10.

Drawing 1



Drawing 2



T-AN1: FIRST AUTO NEGOTIATION (METAL CABLE)  
 X-AN: AUTO NEGOTIATION (FIBER OPTIC CABLE)  
 T-AN2: SECOND AUTO NEGOTIATION (METAL CABLE)  
 DONE: AUTO NEGOTIATION COMPLETED  
 T-DIS: MISSING LINK (METAL CABLE)  
 T-DIS: MISSING LINK (FIBER OPTIC CABLE)

Drawing 3

